Empirical and Theoretical Characterization of Multioctave Planar Phased Arrays

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Introduction

• Characterization of *Multioctave Planar Phased Arrays (MPPA)* has been by indirect and incomplete methods due to high cost and complexity
  – except for flared-notch elements under development since 1980

• This paper discusses theoretical and empirical characterization of an MPPA called *Traveling-Wave Antenna (TWA) Array*, or TWAA.

• Performance: **2-12 GHz, ±60° scan** (E & H planes)
Traveling-Wave Antenna Array (TWAA)

- 16×16-element
  - Scalable to other frequencies & numbers of elements

Front view

Back view showing 256 SMA feed connectors


## Key differences between TWAA and Other MPPAs

<table>
<thead>
<tr>
<th>Features</th>
<th>TWAA</th>
<th>Other MPPAs</th>
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<tbody>
<tr>
<td><strong>Bandwidth and scan angle</strong></td>
<td>Inherently wide bandwidth and scan angle</td>
<td>Limited in achieving both wideband and wide scan simultaneously</td>
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<tr>
<td><strong>Dissipative or exotic material (e.g., ferrite or metamaterial)</strong></td>
<td>• Not used</td>
<td>• Often needed/used, thus low producibility</td>
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<td></td>
<td></td>
<td>• Large cost, weight &amp; thickness</td>
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<tr>
<td><strong>Substrates/superstrates of special dielectric property</strong></td>
<td>Not used (standard PCB used only for structural support); thus lower cost, weight, thickness. <em>Easily air cooled for high power!</em></td>
<td>Generally necessary; thus high cost, weight, thickness. <em>Difficult to air cool, thus low power handling!</em></td>
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Empirical Characterization

- Far-field tests on sufficiently large array (16×16 elements)
- 2-18 GHz BSN (Beam Steering Network)
  - True-Time-Delay (TTD) lines using phase-matched semirigid coaxial-cable corporate feed network
- Discrete TTD lines
- Scan to
  - 0°, ±30°, ±45°, ±60°
- Test over 2-12 GHz
- 0.25 GHz increments
Theoretical Characterization

• Simulated gain patterns generated by ElectroScience Laboratory (ESL) of Ohio State University (OSU)
  – multiplying array factor and Scan Element Gain (SEG) patterns of infinite array using commercial software based on moment-method.

• Simulation for transmit mode, with special attention to feed structure and equivalent source.

• Simulation data not generated for
  • large scan at 60°.
  • below half-space—beyond (-90° to +90°)

(due to limitations of software, computer and infinite-array model)
Good array scan performance in both E and H planes (measured vs. OSU simulation) (H-plane cases shown)
Good array scan performance in both E and H planes (measured vs. OSU simulation) (H-plane cases shown)

8 GHz
5 dB/DIV

No simulation data for -60° scan

12 GHz
5 dB/DIV

No simulation data for -60° scan

8 & 12 GHz, H-Plane
Good E & H-plane scan gain (measured versus calculated)
Conclusions

• Good agreements between theoretical and empirical performance—except for numerical modeling for wide scan beyond 45°.

• Measured data beyond 45° scan revealed
  – Severe limitations in computing for wide-angle scan beyond 45° (due to software and computer)
  – TWAA’s potential for wider scan-angle than conventional planar phased array.